The Diagonal

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THE DIAGONAL

Edited by JAY HAMBIDGE

An illustrated monthly magazine devoted to the explanation of the rediscovered principles of Greek design, their appearance in nature and their application to the needs of modern art.

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THE DIAGONAL

THE TRANSITIONAL DESIGNERS of CLASSIC GREECE

BEFORE we can appreciate the astonishing products of Greek design of the great period, it is necessary that we should consider with some care the signed works of those men who mark the transition from the Archaic Greek to the time of full classic flower. The men whose work we must especially consider in this connection are Amasis, Exekias, Tleson, Nikosthenes and Andokides. In the Louvre there is an extraordinarily handsome oinochoe signed by Amasis and in the Bibliothèque Nationale a remarkable amphora. The oinochoe in the Louvre has, on one side, a mysterious mark which, so far, has baffled the archaeologists. As we shall see later, this mark supplies a possible means of recovering an actual Greek method for the determination not only of general proportions but the subtle and beautiful curve forms. The Louvre also possesses one important amphora by Exekias, three by Andokides, one unsigned, and some twenty-five signed works by Nikosthenes. The latter we shall consider first, as they furnish us the best record so far obtained of the work of a man who changes his symmetry method. Nikosthenes apparently began his career by using static proportion and later changed to dynamic. There is no question about the superiority of this latter work. The archaic designer Tleson has already been discussed in THE DIAGONAL.

The measurements of these designs were made by Mlle. Jeanne Evrard of the Louvre at the suggestion of M. Pottier, Keeper of Greek vases. Mlle. Evrard knew nothing of Dynamic Symmetry. She made the measurements while the writer was absent from Paris, consequently we may regard her work as quite without prejudice.

The study of these amphorae by Nikosthenes in the Louvre, shows us that he was constantly varying his proportions, without, however, departing far from a general base or form recipe which seems to have been original with him. Across the body of these amphorae we notice three emphasized lines which appear to have been the subject of much thought. One of these lines marks the juncture of the neck with the bowl; the other two are raised bands formed by the fabric of the vase body itself. In every Nikosthenes amphora so far inspected, these lines are part of the general proportioning scheme. The distance from the base to the line made by the juncture of the neck with the bowl in F 106 is equal to the width, including the handles. This width is .204. The height measurements are given by Mlle. Evrard at I and show that the height of this line from the base, with the full width, produces the square IJ. The line from I to O is a diagonal to two squares. It cuts the topmost band at P. The construction shows that the height of this band, from the base, with its width, produces another square. The width of this band varies for four diameters from .166 to .168; the heights from .166 to .171. The variations in the figures show us the exact error of the architectural construction.

KJ is a diagonal to the major area. Two such diagonals cut each other at L, the center of the shape. The second band-line passes through this point.

The overall or major area is composed of a square and a third of a square. If the full width is .204 then the height is .272. In diagram *1a*, the height measurements made by Mlle. Evrard are shown at the left; the widths at the right. Even slight inspection will show us that these figures, without a geometrical plan, furnish the exact symmetry of the amphora.

The width of the foot and its height up to the base of the ring, which marks the juncture of foot and bowl, give us the side and end of three squares.

In Fig. *1b* the relationship of these three squares with the rest of the design is made more apparent. HG is a square and BP three squares or one-third of HG. The line QR is equal to RS. The point E is the center of the area PQ. This area, equal to one-half of the area of three squares PB, is itself equal to a square and a half. EQ is equal to one-fourth of PQ and consequently is a square and a half or a similar figure.

AB is a square and HO one-third of that area or three squares. IJ is one of these squares. It was doubtless intended that the width of the neck at its narrowest should be one-third of the total width. The points L and K are fixed by diagonals to the area DN, *i.e.*, an area

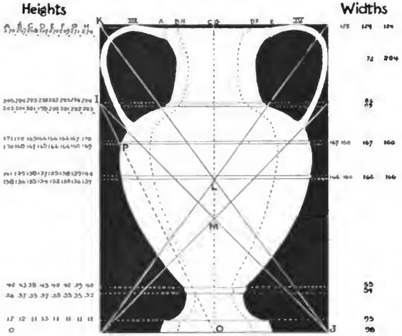


Fig. 1*a*

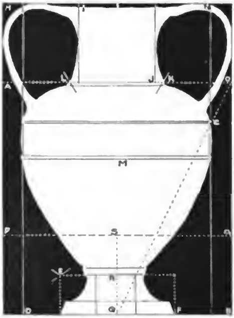


Fig. 1*b*

Fig. 1*c*

defined by the height of the vase and its width, minus its handles, or an area evidently intended to be one and two-thirds.

Amphora F 101, like F 106, has the neck and bowl juncture fixed by the total width. BT is a square and BR a diagonal to its half. This line cuts the upper body-band at Q. This band is the side of another square.

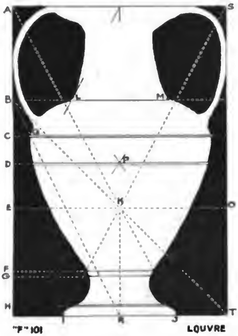


Fig. 2*a*

Fig. 2*b*

The point P is the center of the major area. This fixes the height of the lower body-band.

K is the center of the square BT. Lines drawn from A and S through K and continued to I and J determine the width of the foot. The height of the foot, to the base of the ring joining it with the body, is one-third of the foot width; or this height and width give us three squares, see F 106.

From the center of the lip of the vase draw lines to E and O. These lines fix the width of the neck and body juncture on a side of the square BT, at L and M.

Judging from the other similar amphorae in this collection, the overall shape is composed of the square BT and the area BS, this latter consisting of two squares and a third of a square.

The measurements of the vase are:

Heights A .309, .309, .310, .307, .308, .306, .310, .309.
" B .209, .209, .210, .207, .215, .203, .210, .210.
" C .177, .178, .182, .179, .184, .181, .184, .182.
" D .156, .153, .153, .153, .153, .156, .157, .152.
" F .046, .048, .044, .045.
" G .042, .037, .038, .040, .034.
" H .013, .010, .010, .011.

Widths A .216.
" B .096.
" C .187.
" D .181.
" F .071, .071, .071, .071.
" G .064, .062, .061, .062.
" H .096 (see neck with bowl).

Foot width .114.

Note the unusual arrangement of figures on the bowl.

Amphora F 107 shows us a peculiar if not successful experiment. The handles are compressed to equal the width of the body.

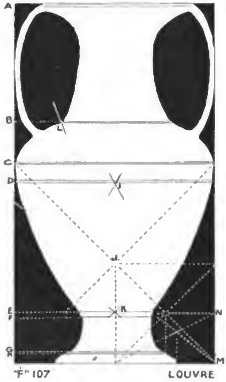


Fig. 3a

Fig. 3b

The upper body-band defines the square CM. I is the center of the major area and fixes the height of the lower body-band.

The square JM fixes the proportions of the foot.

The proportions of the neck and body juncture are determined in the same manner as F 103.

The overall proportion is one and four-fifths, .315 divided by .177. A diagonal to the four-fifths area above the square CM cuts a line from J to A at L.

Mlle. Evrard's measurements for this vase are:

Heights A .318, .318, .316, .315, .318, .314, .316.
" B .212, .212, .211, .214, .211, .215, .211, .213.

" C .178, .178, .183, .178, .181, .178.
" D .158, .160, .151, .161, .157, .158, .156, .153.
" E .040, .041, .041, .046, .045, .041.
" F .038, .035, .039, .038, .039.
" G .007, .010, .010, .009, .011.
" H .006, .008.

Widths A .177.
" B .098, .098, .097, .100.
" C .178.
" D .175.
" E .067.
" F .063.
" G .086.

Foot widths .107, .108, .108, .107.

The overall area of amphora F 103 is composed of a square and two-thirds, .185 divided into .3082.

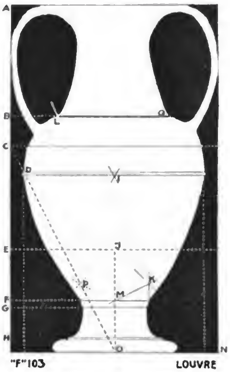


Fig. 4*a*


Fig. 4*b*

Height of the upper body-band, with the full width, gives us the square CN.

CO is a diagonal to half this area; it cuts the lower body-band at D. This band, with the line IO, furnishes another square. I is the center of the major shape.

EN is composed of two squares. M is the center of this area. A line from E to N cuts CO at P. The points P and K fix the width of the foot and bowl juncture.

The foot width was probably intended to equal one and two-thirds of the full width.

J is the center of the square CN. Lines from J to A cut diagonals to the two-thirds area above the square CN, at L and Q, to fix the height and width of the neck and bowl juncture.

Mlle. Evrard's measurements for this vase are:

Heights	A	.308, .310, .307, .310, .307, .309, .307, .307.
"	B	.210, .211, .208, .215, .209, .210, .208, .212.
"	C	.184, .187, .183, .186, .182, .185, .180, .183.
"	D	.160, .161, .158, .161, .158, .161, .157, .159.
"	F	.043, .045, .042.
"	G	.037, .040, .036, .036.
"	H	.012, .013, .013, .013.

Widths	A	.185.
"	B	.100.
"	C	.159.
"	D	.163.
"	F	.060.
"	G	.055.
"	H	.86.

Foot width .112.

In amphora F 104 we see a characteristic variation on F 106. The square CJ is made by the top of the upper body-band. This band, as will be seen by the photograph, is considerably distorted, a defect probably caused in baking. One of the heights, however, is given by Mlle. Evrard as .203, the exact full width.

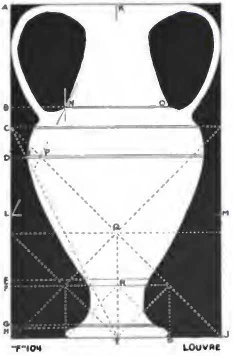


Fig. 5*a*

Fig. 5*b*

The line CT is a diagonal to half a square and it cuts the lower band-line at P. The heights of this line from the base are:

.176, .172, .172, .173, .175, .173.

The widths: .173, .173, .175, .173.

The height of the foot to the bottom of the ring covering the juncture of the foot and bowl is: .050, .053, .050, .053, .053.

The foot width is .101. This height and width are the end and side of an area composed of two squares.

The lower band-line length, with its height from the base gives us another square.

The full width is .203. The foot width was undoubtedly intended to equal one-half the full width.

The major area, in excess of the square CJ, is equal to a square and three-quarters. This is interesting as it shows a method of handling static proportion analogous to that employed with dynamic shapes shortly after the transitional period. When Dynamic Symmetry appeared in Greece the ground was apparently thoroughly prepared for its reception.

The widths of the juncture line of neck and bowl at the base are given as .102, .103, .103, .102. This line is equal to the width of the foot.

AM is a square applied from the top. KL and KM are diagonals to half this square. These lines cut the neck and body juncture at N and O and fix its width. Mlle. Evrard's measurements are:

Heights A .319, .321, .318, .322, .319, .321.
" B .219, .217, .220, .218, .222, .221.
" C, bottom of band, .200, .196, .202, .201, .197, .197.
" D .176, .172, .176, .172, .173, .175, .173.
" E .057, .055, .058, .062, .061, .058.
" F .050, .053, .050, .052, .056, .053.
Widths B .102, .103, .103, .102.
" C .165, .168, .166, .163.
" D .173, .173, .175, .173.
" F .064, .064.
" G .079.
" H .083.
Foot width .101.
Full width .203.

[To be continued.]

From an unsigned and unnumbered figured cup in the Louvre.

DYNAMIC SYMMETRY OF THE HUMAN FIGURE FOR ADVANCED STUDENTS

OF all the examples of very early Greek archaic sculpture of the figure the celebrated Tenea Apollo in the Museum at Munich is in the most perfect condition and furnishes, therefore, an admirable subject for symmetry analysis. The statue was found in 1846 on the site of Tenea, near Corinth. It was originally in the possession of Baron Prokesch von Osten, from whom it passed, in 1854, to the Glyptothek, Munich, where it now is. The measurements on which the present analysis is based were taken from a full-sized cast in the Museum of Fine Arts, Boston. When found the statue was in almost perfect preservation, only a piece of the right arm being missing. The figure, however, as we learn from the abundant remains of similar statues, belongs to a type the original of which is supposed to be Egyptian. The statue of Amenophis IV of Egypt is such a prototype. In both cases we have the same general attitude of a man standing stiffly upright, both hands held against the body and the left foot in advance of the right. According to the Sicilian historian Diodorus, the early Greek sculptors acquired knowledge of their canon for figure proportions from the Egyptians. The Glyptothek catalogue gives this description—"Apollo of Tenea,

Height 1.53 m.

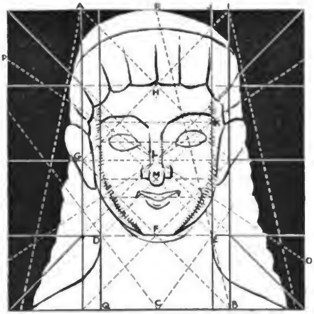
Length of face 0.142 m.

"In the determination of the bodily proportions the foot of the figure seems to have

served as the basic measurement. The lower legs are two feet long, the height of the head is one foot. From the end of the chin to a line connecting the nipples, from there to the navel, and from the navel to the fork, is each one foot long.

"The statue is to be dated in the neighborhood of 600 B. C. Probably a work of Dipoinos and Skyllis, or of their school." Others date it considerably later.

We cannot say that the length of the foot was the basic measurement, as the feet are of different lengths. The right is .2020 while the left is .2075. When we measure the full height and greatest width, we find that the lesser measurement is contained in the greater three and two-thirds times. The height is 1.5352 while the width is .4187.* Assuming that the statue was cut from a prepared rectangular block of marble this block, if it exactly contained the figure, would have as front elevation an area composed of three squares and two-thirds of a square; the side elevation would be a proportional part of the front elevation, as shown in III of Fig. 1. When we divide the front elevation area as in I, Fig. 1, we find that we can actually draw the figure with great precision. The area AD is composed of the three squares, while DE is two-thirds of a square. The top line of the three squares AD passes through the base of the neck.



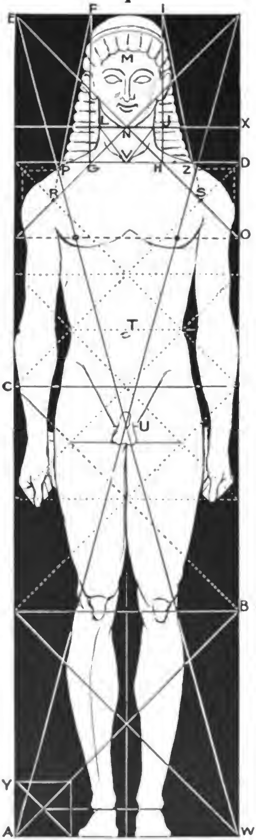
Head of the Tenea Apollo

This is a square taken from the center of the two-thirds area of the front elevation. AB is composed of two squares. DC, CE are diagonals to the half of the two-thirds area. Lines through E and D fix the two-square area DJ. DK is one of these squares and M is its center. F and H are apparent. P and O and its companion line in the other direction are diagonals to the entire two-thirds area. The complicated lines of this diagram are really not necessary, as the proportions could be fixed with a few of them. They are given to show that there is a persistent interrelationship of proportion.

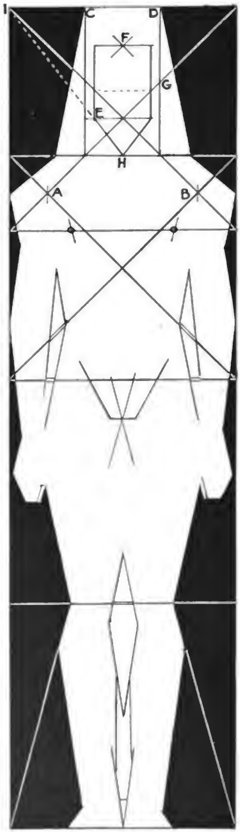
If we apply the square EO to the top of the façade rectangle, the center of this square is the point of the chin. The diagonals of this square cut the top of the three squares AD at G and H. These two points enable us to divide the area ED into three equal parts, each

* The slight variation between the Munich height measurement and that on which this analysis is based is justified by the fact that the figure is not standing level. The 1.5352 height is more correct than 1.53 of the Munich catalogue.

I



II



consisting of two squares, EG, GI and ID. The area GJ is composed of two squares, JF a square and a half. M, the line of the hair on the forehead, is the center of one of the squares of FH. The center of the other is N. The lines BL and BJ are diagonals to half of the area ED. The points L and J give us the width of the neck and enable us to fix the proportions of the face. The large scale head of Fig. 2 shows this in detail. AB is the two-square area of I, Fig. 1, and DC, CE are diagonals to half of the two-thirds area. Lines through these points fix the new double-square area DJ of Fig. 2. The simplest method for determining this latter area would be to draw a line from B to R, this point being midway between A and I. The line RB is a diagonal to four squares. EB is also composed of four squares. RB was evidently intended to pass through the center of the eye. One eye is a trifle higher than the other, so this point must remain unsettled. When the figure façade is charted out as described we notice the following points:

The nipples are fixed on the base of the square EO by diagonals to the whole cutting this line. The exact center of the major rectangle is at U. The waist, at its narrowest, is equal to half the width of the figure or the full length of the head from the chin to the crown. The hands and arms are unequal, the right being slightly longer. The hands were probably intended to reach a line through the center of the square CB. The lower legs are equal to the full width of the rectangle, a side of the square AB passing through the patella. The width of the shoulders is fixed by P and Z. It was undoubtedly intended that the length of the foot should be equal to half the full width or to half of a side of a unit square, but the statue from the knees downward is overworked. From the knees upward the statue rigidly follows a static canon. From the knees to the base it would seem that the sculptor studied an actual model. Both feet and lower legs have the characteristic appearance of a slightly timid overworking, as we find in the arm of the Delphi Charioteer. This overworking would account for the length difference between the feet.

Fig. 1 is an illustration of a possible marking off of the façade of the marble preparatory to sawing off or pointing out excess material. It is apparent from this arrangement that the finishing of the statue would have been a fairly simple matter.

The statue furnishes us with all the characteristic features of a canon of proportion or symmetry but it is static. The statue of Amenophis IV, undoubtedly a prototype, is dynamic. The ratio for the Tenea Apollo is 3.666; for the Egyptian prototype it is 3.618. These two statues show us clearly that the Greeks, in the Tenea figure, had only the shell of the Egyptian system. It must have been soon after this, however, that they acquired full knowledge. When this happened it did not take them long to go far ahead of their Egyptian masters.

In III, Fig. 1, we have a side elevation of the Apollo. A diagonal to the whole, *i.e.*, the three and two-thirds area of 1, cuts the line BH to fix the area GF. The area AB is a similar figure to the whole.

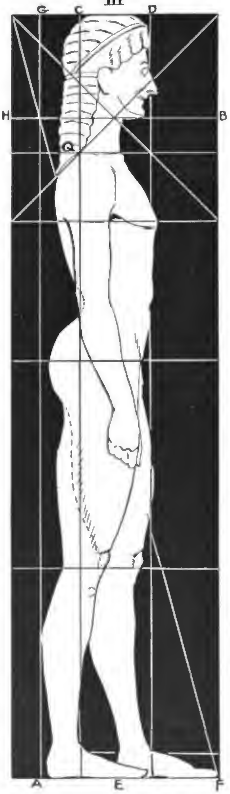
In IV and V, Fig. 1, the front and side are shown in their relationship to what would be a modern subdivision of the overall area into thirty-three squares or an area three by eleven. Very little of this arrangement seems to have been used by the Greek sculptor.

Artistically the Tenea Apollo can have but slight interest for us, but historically it is most valuable. It is from sources such as this that we shall learn the ways and means employed by the Greeks when they started on the road which led to such astonishing achievement in art. It will be noticed that this early archaic sculptor apparently used a process of area subdivision of a like character to that which we find in the work of the designer Nikosthenes or Tleson. In fact, the method of area manipulation which we find in the old Greek static design shows a high degree of ingenuity and design cunning. Nikosthenes, in his early work, is apparently constantly alert for subtle and hidden squares. These early designers seem to have thoroughly understood the effect of area union on generating forms. In fact, the cunning

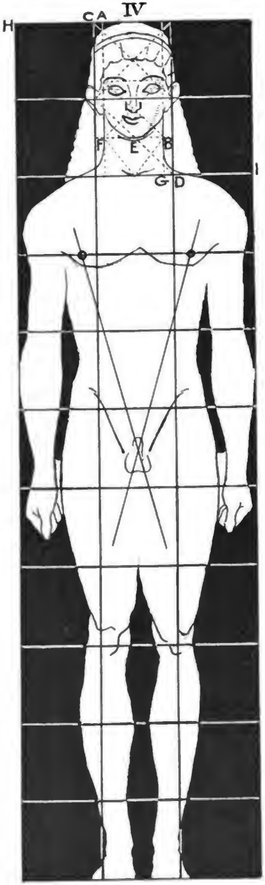
we find in Greek static design is quite of a piece with that observable in the dynamic fabric. The ground was well prepared for the reception of the great idea later.

[To be continued.]

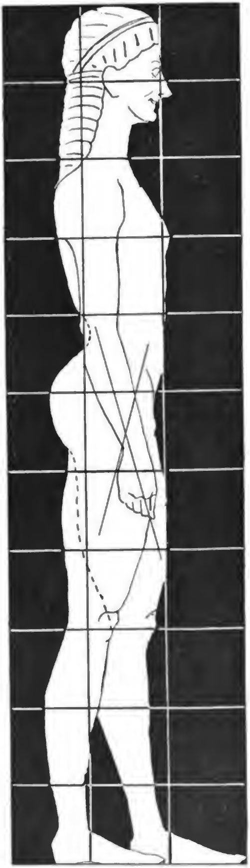
III



IV



V



THE ELEMENTS OF DYNAMIC SYMMETRY

Much of the work upon which the Elements of Dynamic Symmetry is based was done during the year 1919 under the Sachs Research Fellowship of Harvard University. This fellowship was founded by Samuel Sachs of New York City and, under the terms of the foundation, is assigned to scholars of proved ability, whether students, instructors or others, for the general purpose of advancing the Fine Arts. This acknowledgment is but a faint expression of the writer's appreciation of the benefits enjoyed from a fellowship of a type too rare in American Universities. JAY HAMBIDGE.

RATIOS MOST FREQUENTLY USED, THEIR RECIPROCALS AND SIMPLE DIVISIONS

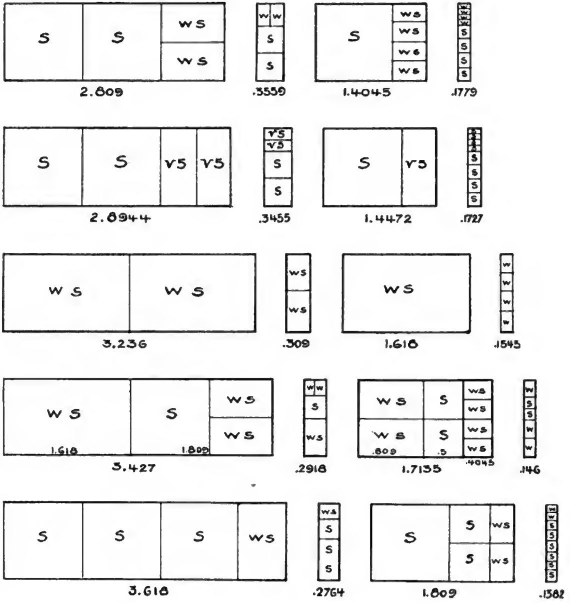


Fig. 2

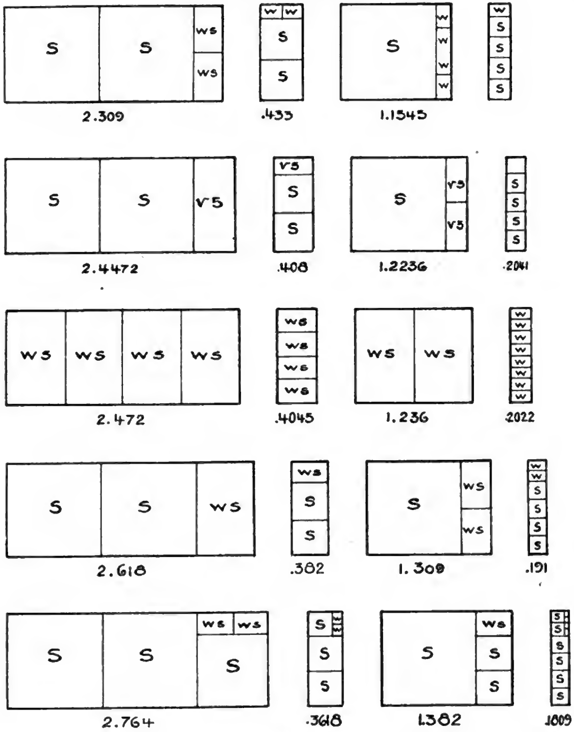


Fig. 1

See July Diagonal for a description of the ratios in the above diagram.

FREQUENTLY it is necessary to construct odd compound rectangles within a square, especially so when turning corners. The simplest and most direct method for this purpose is that of constructing the required figure, minus a square, outside of a square, and then drawing a diagonal to the entire area. For example, if it is required to fix a 2.309 rectangle within a square the process is to draw a 1.309 shape outside a square as in Fig. 3.

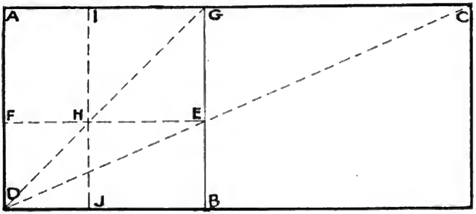


Fig. 3

AB is a square and BC a 1.309 rectangle. DC is a diagonal to a 2.309 area; *i.e.,* 1.309 plus 1. This diagonal cuts a side of the square AB at E. Draw EF parallel to DB. The area DE is a 2.309 rectangle within the square AB, *i.e.,* DE is the reciprocal of DC.

The nature of the area AE is found when we fix the numerical value of the line DF. This is the reciprocal of 2.309 or .433. In Fig. 2 the line AD equals 1, DF .433 and AF the difference between .433 and unity or .567; this is a reciprocal ratio, being that of 1.764 minus. The fraction .764 is the reciprocal of 1.309. Therefore the area AE is equal to a square, HG, and a 1.309 rectangle, AH.

AJ is a 2.309 area, being the reciprocal of DC. If the square DH is subtracted from AJ then AH equals 1.309.

GJ is a similar figure to AE and JE is similar to AH.

We frequently find in Greek design curious compound figures such as 1.691. This ratio, for example, is composed of a square plus a square and a root-five rectangle, .691 being the reciprocal of 1.4472. If we had a plan wherein .691 areas were arranged along the bounding lines of a dynamic area as in Fig. 4, AB might be such a rectangle, CD and EF .691 rectangles.

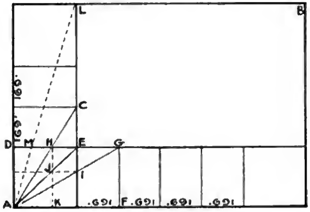


Fig. 4

AC and AG are diagonals to 1.691 rectangles, AH and AI are 1.691 areas within the square AE, and DI, IK are .691 shapes. AJ, JE are squares.

AL is composed of two 1.691 areas or 3.382. If we draw a line from A to L it cuts DE at M. The area AM is a 3.382 rectangle and the reciprocal of AL.

If we wish to determine a 2.4472 area inside a square we construct a 1.4472 area outside the square and draw a diagonal to the whole.

Angle square	Area outside	Resulting ratios	
1	1.618	2.618	
1	.691	1.691	
1	.7236	1.7236	
1	.764	1.764	
1	.809	1.809	
1	1.809	2.809	
1	2.809	3.809	
1	1.191	2.191	
1	2.191	3.191	etc., etc.

[To be continued.]

A Modern Vase in the Luxembourg without Design or Proportion.

THE SPIRAL AND OTHER CURVES OF DYNAMIC SYMMETRY

IT will be necessary for students of Dynamic Symmetry to construct geometrically the logarithmic or constant angle spiral. As was mentioned in early numbers of THE DIAGONAL, this curve appears to be the growth curve in plants. Inasmuch as the middle one of any three radii vectors, equiangular distance apart, is a mean proportional between the other two, we are able to draw this mathematical curve with ease and accuracy.

The first geometrical discovery made by the Greeks, in fact the first general law discovered by man, of which there is record, was that the angle in a semicircle is a right angle. Fig. 1 makes this clear.

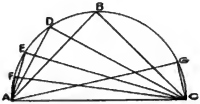


Fig. 1

ABC is a semicircle and AC is a diameter. BAC is a right angle. So also are DAC, EAC, FAC, GAC and so on.

Another great discovery, made later, was that a line dropped from the juncture of the two legs of a right-angled triangle to meet the hypotenuse was a mean proportional between the two segments of the hypotenuse as cut by this dropped line.

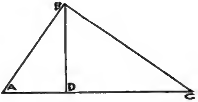


Fig. 2

BAC, Fig. 2, is a right-angled triangle and BD is a mean proportional between AD and DC. By the principle inherent in Fig. 1, the line AC of Fig. 2 is a diameter to a circle and the points A, B and C lie on the circumference of half of this circle.

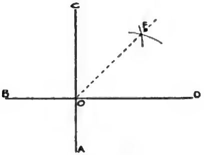


Fig. 3a

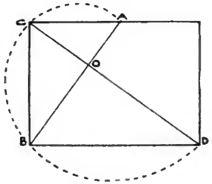


Fig. 3b

Suppose A, B, C and D, Fig. 3*a* and *b*, are points on the curve of a logarithmic or constant angle spiral and OA, OB, OC, OD are radii vectors equiangular distance apart. By definition OC is a mean proportional between OB and OD. Or OB is a mean between OA and OC. But suppose we wish to find points on the curve other than A, B, C and D; say between C and D. In that case we must find a mean proportional between OC and OD.

This is done by bisecting the angle DOC. A line is drawn equal in length to DO plus OC, Fig. 4.

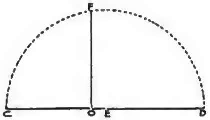


Fig. 4

This line is bisected at E. Then CE is equal to ED. With radius equal to CE or ED describe the semicircle CFD and, perpendicular to CD, draw the line OF. This line OF is a mean proportional between CO, OD, and F, Fig. 3*a*, is a point on the curve.

To find other points on the curve bisect angles like DOF or FOC, then add together the lines DOF or FOC, bisect them as described in Fig. 4, construct on these added lines as diameters a semicircle and draw the required mean proportional line as described. By this process any number of points may be found on the spiral curve.

In geometry a mean proportional line is equivalent to a square root. By definition a mean proportional line is the side of a square equal in area to the rectangle contained by the two extreme lines. If we construct a square on the line OC of Fig. 3*a*, this square is equal in area to the rectangle made by OB as end and OD as side. That is, the line OC is the square root of DO, OB.

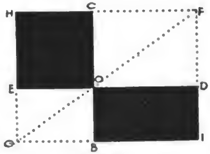


Fig. 5

The simple geometrical proof that the square CE is equal in area to the rectangle OB is obtained by completing the rectangle of which GF is a diagonal.

The triangle HGF is similar and equal to GIF.

ODF is similar and equal to OCF.

GEO is similar and equal to GBO.

Consequently the area CE must be equal to the area DB.

In Fig. 3*b* we have a rectangle with a diagonal to the rectangle and a diagonal to the reciprocal; they cut each other at right angles at O. Because of this OA, OC, OB, OD,

are points on the curve of a logarithmic or equiangular spiral. OC is a mean proportional between OA and OB, and OB bears the same relationship to OC and DO. We find other points on this curve by the process described above. By definition the lines OA, OC, OB and OD are in continued proportion. That is, OA is to OC as OC is to OB and OC is to OB as OB is to OD, and OC, OB are two mean proportionals between OA and OB. In other words, these lines furnish us with a graph of the simple rule of three. If we substitute numbers for these lines their relationship will be more obvious. Suppose we give OA the value of two and OC four; then OB must be eight and OD sixteen. Four and eight are means and two and sixteen are extremes. In four terms in continued proportion the product of the means is equal to the product of the extremes. Four multiplied by eight equals thirty-two; so does two multiplied by sixteen. OA, OC and OB are three terms in continued proportion. According to the numerical value given to these lines OC multiplied by itself or squared is equal to OB multiplied by OA. Four times four equals sixteen and twice eight equals sixteen. But we may draw a logarithmic spiral within a rectangle.

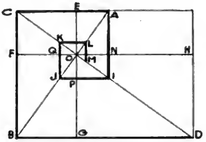


Fig. 6

In Fig. 6, O is the pole of a logarithmic spiral determined by the line BA crossing CD at right angles. Through this pole we may draw the lines EG and FH. H, G, F, E, N, P, Q, etc., are points on a logarithmic spiral curve contained in the rectangle CD and other points on this curve may be found as described above.

It is suggested that the student draw and redraw these simple diagrams until he thoroughly understands the principles involved, as he will find they will prove of great help to him in future work.

During the entire period of Greek classic design the construction of the spiral curve seems to have been a matter of constant experiment. A comparative study of the Ionic volute makes this fact clear. Fig. 7 shows the construction of volutes of different kinds by straight lines. Having a satisfactory volute arrangement in straight lines the construction of the curve is a

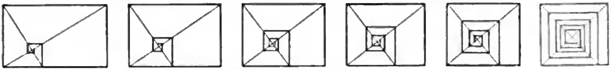


Fig. 7. Spiral and Other Curves.

very simple matter; it may be made free hand, by circle arcs of varying radii or by geometric construction as previously described. Of course the actual Ionic volute was in a rectangle which was some logical division of the rectangle which contained the entire column and this again was a logical part of the shape which contained the entire building.

Fig. 1*a*

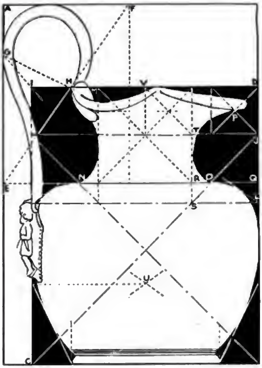


Fig. 1*b*

Small Bronze Oinochoe, British Museum, W. T. 656.

H.—H.	.1400 ±	1.2071	H.+H.	.1820 ±	1.4142
W.—H.	.1160—		W.+H.	.1300 ±	

Measured, drawn and photographed by C. O. Waterhouse of the Museum Staff.

BRONZE OINOCHOE IN THE BRITISH MUSEUM

ANOTHER bronze oinochoe in the British Museum furnishes ratios which show a theme in root-two (see June and July DIAGONALS).

Height including the handle	.1820	ratio 1.4142
Width including the handle	.1300	
Height minus the handle	.1400	ratio 1.2072
Width minus the handle	.1160	

The details of this example, in at least one particular, seem to have been correlated by a blending of the proportions of the two root-two forms.

The overall rectangle, including the handle, is a root-two rectangle. The line EQ divides this overall area into two equal parts. Consequently the area AQ is a root-two rectangle. But EQ defines the height of the bowl of the oinochoe.

A 1.2071 rectangle of the required proportion for this example is constructed within the major root-two area as follows: within the root-two rectangle AQ defines two squares. GQ is a diagonal to these areas and it cuts a diagonal to the root-two shape EF at H. Through H, parallel to EQ, draw ID. The line GW is a diagonal to a root-two rectangle and two squares; *i.e.*, it is a diagonal to a 1.2071 rectangle. The composition of this ratio is .7071, a root-two area, EW, and .5 or two squares, GQ. .7071 plus .5 equals 1.2071. The line GQ cuts ID at I, consequently IW is a 1.2071 area because IW is common with GW.

CJ is a square and IJ is composed of two squares and two root-two rectangles.

VQ is composed of two squares and a root-two rectangle. RD is the root-two area and RV the two squares.

IQ is double VQ or IJ.

CL is a root-two rectangle and U is its center.

IL is composed of two squares.

MR is a square.

ML is a curve tangent. Other curve tangents are apparent.

S and U fix the height of the figure at the base of the handle.

Points O, N, H and P are apparent.

The line ID, minus IH, multiplied by two gives the width of the foot.

The Editor wishes to announce that hereafter he will be pleased to answer questions relating to "Dynamic Symmetry" or to the matter which has appeared in THE DIAGONAL. *It is requested that correspondents make their communications as short as possible.*

Willesden, Holywood, Co. Down, Ireland, 4th July, 1920.

Dear Sir:

Since writing you a few days ago I have been looking for some reason why so large a percentage of Greek art is, as you say, based upon the $\sqrt{5}$ rectangle; and I have found a rectangle, based upon the $\sqrt{2}$ rectangle, which is very nearly a $\sqrt{5}$ rectangle and it seems to me that possibly, at least in some cases, what has been attributed to a $\sqrt{5}$ rectangle might really belong to this other rectangle. I estimate that for the same width the difference in length is about ¼ per cent. The new rectangle is formed from a $\sqrt{2}$ rectangle as follows:—add to each end the difference between the length and width. Then $\frac{\text{width}}{\text{length}}\frac{1}{\sqrt{2}+2(\sqrt{2}-1)}=\frac{1}{3\sqrt{2}}-2=\frac{1}{\sqrt{5}}$ approx.

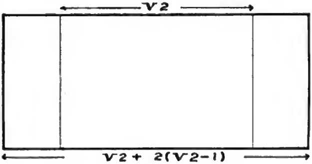


Fig. 1

I enclose a tracing of this rectangle to show the connection with the $\sqrt{2}$ rectangle and its wonderful properties.

Yours very truly,

ARCHD. H. FINLAY.

Jay Hambidge, Esq., 14 Place Vendome, Paris.

The reason why such a large percentage of Greek design is based upon the root-five rectangle apparently lies in the fact that a diagonal to two squares was preferred by the majority of classic artists to a diagonal to one square as a means of producing areas which could be subdivided easily without resulting in incommensurability. It should be remembered, however, that the root-five rectangle, *per se*, is seldom found. This applies also to the whirling square area, which is a derivative of the root-five shape. This latter area is a base to which the multitude of compound forms of this highest symmetry type may be referred. Occasionally compound arrangements of the root-two base are found which very closely approximate ratios of the root-five base, but so far no confusion has resulted from this, as the general overall shape of a design is considered of no particular importance unless all the

details reveal a theme. A case in point was furnished by a vase in the Boston Museum of Fine Arts. Dr. Caskey, of the Museum, measured this vase and concluded it was a root-two shape; but the example failed to respond to any type of root-two analysis. The example was given to the writer for further inspection. The successful analysis showed that the shape, instead of being 1.4142 was 1.4045 or a square plus four whirling square rectangles. This point of approximating ratios was ably discussed by the American artist, Mr. Rutherford Boyd, before a meeting of the American Institute of Architects in the spring of 1919. He showed that areas so close to each other in shape that the eye could scarcely distinguish their difference, were yet absolutely different when subdivided into their logical units.

The ratios 1.7082 and .7082 are hardly to be distinguished from 1.7071 and .7071 as plain shapes; yet as subdivided they are unmistakably different.

In previous numbers of THE DIAGONAL the work of the sixth century B. C. Greek designer Tleson was discussed. This designer, at one time, used static symmetry in the form of a square or squares divided into even multiples very much as modern designers do. He changed from this system to one based upon root-two and examples of his creation show the process of the change. The designer Nikosthenes, one of the most prolific producers of all the sixth century B. C. designers, if we are to judge by the number of examples of his work which have survived, began by using static symmetry in a much more subtle and complicated manner than did Tleson. Nikosthenes also changes his method. There are twenty-five examples of this designer's works in the Louvre, part of which are static and part dynamic, and there is a large kylix in the Metropolitan Museum, New York, which is transitional. So far there is no evidence that Nikosthenes used the root-two base. His early work is static, based upon relationships of squares and even multiples. His later and best efforts are formed upon the root-five base. So far nothing of a root-two flavor has been found. There are two signed works of Amasis, a Greek meteque with an Egyptian name, in Paris. They are superlative works. One example is a pure whirling square arrangement, the other a 1.309 shape. Amasis is supposed to antedate both Tleson and Nikosthenes. The handsome amphora by Exekias in the Louvre is a simple root-two arrangement. Three wonderful amphorae in the Louvre by Andokides, two of which are signed, are based upon the root-five or double-square symmetry. Exekias is supposed to be later than Amasis and earlier, slightly, than Nikosthenes. Andokides is probably somewhat later than any of those mentioned, though he produced black-, white-, and red-figured designs and therefore is a true transitional artist.

It would be pleasing to the writer, and from expressions he has heard, to many American artists, if it could be proven that the Greeks did not use the double-square symmetry, as we may temporarily call the root-five base. So far, however, the evidence seems to be overwhelmingly the other way. If we found more pure root-five shapes in Greek design a confusion between the shape suggested by Mr. Finlay might at times exist. Readers of THE DIAGONAL will appreciate the closeness of the two areas if they are expressed arithmetically. The square root of five is 2.23606. The compound root-two form is 2.2426; *i.e.*, 1.4142 plus .8284. If it could be shown that root-two was the predominating base of Greek design, the fascinating natural growth base, as furnished by the law of phyllotaxis or leaf distribution, would be removed. The writer confesses that the relationship of this superlative design to natural form is, to him, most important. In his estimation it would be preferable to abandon Greek design rather than to give up a design based upon ratios found in nature.

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